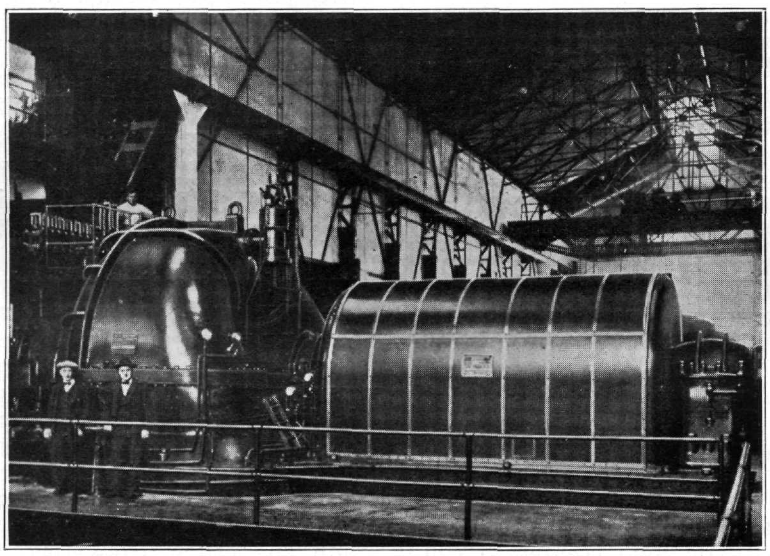
Development of the Steam Turbine

By Walter A. Galloway, '30

Of the large number of people who know something about the steam turbine there are quite a few, no doubt, who think of the turbine the same as they do of most every day occurrences. The purpose of this discussion is to give some idea of the extent to which this type of power conveyor has been developed.

Without some consideration it is very hard for one to realize the conditions which existed in the world before the introduction of the steam engine and the rest of the mechanical devices which followed its discovery. The coming of the steam turbine into the industrial world changed completely the methods of manufacturing. The steam engine, as it was first produced, was a crude affair. Due, however, to the ingenuity of man it has and is being wonderfully improved. The common type of steam engine is rapidly becoming obsolete. Due to the increased efficiency of the steam turbine and its greater capacity for turning cheap fuel into more more useful energy this type of steam engine is taking the place by the reciprocating steam engine.

The turbine has developed a great reputation as being the almost ideal prime mover in all large electric generating stations. The growth of the electrical industry is largely due to the degree to which the turbine has been developed. Up to the present time this type of prime mover has only one dangerous rival, which is the water turbine. Considering the present stage of development of the available water power, however, eliminates this last competitor and leaves us with the steam turbine as the best source of driving power.



20,000-KW., 1500-R. M., 50-Cycle, Curtis steam Turbine-Generators, installed in the Tocopilla Station of the Chile Exploration Company, Chile. This unit supplies power for the mining and smelting of copper

A turbine consists mainly of a large steel shaft on which is mounted a series of wheels somewhat similar to the wheels of a windmill. These bucket wheels are usually of different diameters and the blades at the rims of the wheels vary accordingly. Between each bucket wheel there is a circular plate or disc with its center cut out so that the rotor shaft can pass through. On the outer rim of this disc there are guide blades or nozzles for conducting the steam from one set of buckets to the next. This whole arrangement is mounted inside a casting called the turbine shell. The bucket wheels are held in position by grooves in the shell so that the clearance between the rotor and the nozzles is only a few thousandths of an inch. The shaft is supported on babbit bearings at each end of the shell and is packed with a suitable steam packing.

When the steam enters the first nozzle it hits the first set of rotor blades. When the machine has gained full speed this row of blades is traveling at a velocity in some ratio less than the velocity of the steam. Upon leaving this wheel the steam has lost this ratio of its former speed. As the next diaphragm is larger and of a peculiar curved shape, the steam must expand and increase in velocity. As it passes through each set of blades the steam pressure is lowered and its velocity is increased. This fact shows why the wheels of a turbine become larger and the size of the blades increase in each succeeding stage. Upon leaving the last row of buckets the steam shoots into a large opening called the exhaust hood. This casting is very large so that the steam will be free to shoot out of the fast revolving rotor wheels. From the exhaust the steam is drawn into a condenser. This device is almost as massive as the turbine. It consists of a multitude of water-cooled pipes through which the steam passes and is turned back into liquid. The same water is used to make steam over and over again after this condensing process. In condensing the steam a vacuum is set up in the exhaust hood which allows the steam to be rushed through the turbine much more swiftly. Condensers on the average turbine set will give a vacuum of 29 to 30 inches of mercury. In creating this high vacuum great care has to be taken to keep water from the boilers from being forced through the delicate blades of the machine. The efficiency of a turbine installation depends greatly on the condensers.

The steam turbine places special requirements on all the metals used in its making. Special cast iron is used to the greatest extent. Cast steel is next in the quantity used. Nickle steel is used in practically all turbine shafts. Special stainless steels are used in the bucket blades, and small amounts of brass, bronze, babbit and special

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alloys are required. Scientific research into the properties of metals has been quite a factor in turbine development. To make sure of the nature of the material in each turbine part samples are taken and carefully tested and analyzed in the producers' laboratories. The whole machine is, in the end, of scientific origin and requires the most exact calculations and specifications for its proper functioning. Even after the materials have been found satisfactory the trueness of their application depends on the man in the machine shop, who is actually confronted with the job of making a giant machine with the properties of a delicate watch.

The exhaust hood on a turbine forms probably its greatest mass. The exhaust hood is made out of cast iron and, in a machine with a rating of twenty thousand kilowatts capacity, weighs nearly forty tons. These mammoth castings are annealed in huge ovens to relieve them of cooling stresses and machining and other stresses which might cause cracks or warping in the later life of the turbine.

The shell of the turbine has been changed from cast iron to cast steel. The increased temperature used on turbines of a later date is the cause for this change. The actual pressure on the turbine shell is comparatively small considering the steam pressure used. The quality of permanent growth of iron, when heated and colled often, makes iron very unsatisfactory in the making of turbine shells. Steam pressure of over five hundred pounds to the square inch and temperatures ranging to nearly eight hundred degrees centigrade is very common in the modern turbine.

Turbine shafts were originally made from carbon tool steel, but, due to the development of nickle steel, which gives higher physical properties, the greater part of the shafts are now made from this material. The shaft of the turbine determines the working characteristics of the whole machine. If the shaft is too rigid the wheels will not center up to their theoretical point of revolution. On the other hand, the shaft must be substantial enough to carry the tremendous load of strains imposed upon it. Shafts are turned from steel forgings treated specially in the annealing ovens and if even a slight flaw appears in the process of finishing it must be discarded.

After all the parts are assembled and tested, the turbine is set up in a power station on special foundations. A turbine generating unit may seem perfect on one type of mounting and on another it may almost vibrate visibly. A turbine, in reaching its running speed, passes one or more speeds at which it vibrates more than at any other. Most turbine designers try to have the running speed just beyond one of these critical speeds. A change in the stiffness or elasticity of the foundation has been found to affect the critical speed. The actual operating success of a unit depends on the way the set is suited to its mounting. If the critical speed of the machine is too close to the running speed it may be lowered by decreasing the actual vertical stiffness of the foundation.

Turbines of today range from fifty kilowatt units to immense compound units developing over two hundred thousand kilowatts. In the larger

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machines the steam is used in special high pressure and high temperature turbines and then is passed into other units of lower and lower pressures before it is exhausted into the condensers. Some of these installations reach an efficiency of ninety per cent and over. The present tendency in power stations seems to be toward these gigantic units.

The end of turbine development is far off and the extent of its use is increasing daily. The lights we use and the power that pushes a thousand different kinds of devices in industry comes from, or is destined to have its origin in, the speeding buckets on the rim of a giant turbine rotor.